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Annotated Bibliography on Techniques and Applications of Modelling in Health

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ANNOTATED BIBLIOGRAPHY

on Techniques and Applications
of Modelling in Health

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1 General Articles on Modelling

Title: Modelling Health Sector Resource Allocation Choices
Author: Robert N. Grosse
Source: Department of Population and Planning and International Health, School of Public Health, The University of Michigan, April 1987; V International Congress, World Federation of Public Health Associations, Mexico City, March 22-27, 1987.
Abstract: A major problem to which economics is addressed is the allocation of scarce resources among valued objectives. Our modelling approach is the development of one tool which may be used to project the effects on health status of a population of changes in the ways in which resources are applied and the effects of changes in the quantities of resources.
The approach tries to assist decision makers by organizing available knowledge about the relationships between resource requirements and various preventive and curative programs and between the programs and health status. The model is a calculating device and a framework with which planners can organize the questions, the data, and the tentative conclusions about the nature of the health system and how it can be altered to achieve policy objectives.

Title: Systems Modeling in Health Care - Proceedings of an IIASA Conference
Author: E.N. Shigan
Source: International Institute for Applied Systems Analysis (IIASA, 1978)
Abstract: This conference focussed on the development and practical application of mathematical models of health care systems elaborated at IIASA and its NMOs. The proceedings include papers submitted by the organizers of this conference, reports by the participants from different national and international organizations, and the main content of discussions that took place during all sessions.
The main topics are:
- State of the Art in the IIASA Health Care Systems Modeling Task
- Health Care Systems Modeling by National and International Centers
- Development of National Health Care Systems Modeling
- Planner's Requirements for Models
- Collaboration with National and International Centers

Title: Interrelation Between Health and Population: Observations derived from Field Experiments
Author: Robert N. Grosse
Source: Journal of Social Science and Medicine, Vol 14C, 1980, pp 99-120
Abstract: This paper presents information and concepts concerning the health of populations in less developed countries as background for discussions of more focused and detailed papers on these and related subjects.
It begins with a review of health status and trends in developing countries since 1950, followed by a section identifying the major health problems and their causes.
The third part includes analyses of associations between health resources, water and sanitation facilities, food availability, and economic and social indicators taken as independent variables and measures of health status - life expectancy, crude death rates, and infant mortality - as the dependent variables.
The final section discusses health policies and their implementation and offers an analysis of the resource requirements and health effects of different methods of organizing and combining health programs in a few developing countries. The objective is to illustrate a method of determining preferred activities at any given level of investment and the probable health effects of varying increases in the level of health expenditures.

Title: Dynamic Modelling and Health Policy Research
Author: E.O. Attinger
Source: WHO/RPD/SOC/85, pp. 56-83
Abstract: The recognition that health is not the exclusive domain of the health care establishment is increasing and the need to evaluate the impact of both medical and nonmedical determinants of health in quantitative terms is becoming pressing. The dependence of health on a multitude of factors can only be analyzed by comprehensive, and therefore complex models. The validity of such models rests primarily on the reliability of the

databases available for the assessment of input and output variables. At present these databases are inadequate in most aspects and unreliable in others. The multidimensional aspects of health require access to a combination of age and disease-specific mortality and morbidity data, disability data and data relating to the quality of life. Socioeconomic statistics abound with indicators of the quantity, but not of the quality of inputs and outputs in their respective sectors.

Title: Causal modeling as a relevant approach to gerontological nursing.
Author: Phillips-LR
Source: J-Gerontol-Nurs. 1990 Sep; 16(9): 20-4
Abstract: Causal modeling involves the development of causal hypotheses to explain a particular phenomenon and the testing of causal assertions through systematic data collection and analysis procedures. Although more research is being conducted gerontological nurse scientists have generally failed to logically develop and systematically test theories that unify, organize, and consolidate knowledge into schemes that explain, describe, and predict. Causal modeling combines theory and research, and because the interpretation of data is possible only within the context of the proposed theory, it offers an important method for advancing the science while maintaining the specificity of the practice.

Title: Projection Methods and Software for Future Trend Assessment
Author: J.E. Dowd
Source: WHO Geneva: Division of Epidemiological Surveillance and Health Situation and Trend Assessment, Unit of Monitoring, Evaluation and Projection Methodology; 1990
Abstract: The report is concerned with techniques for developing projections and forecasts of the health status of a defined population. The restriction to projection of health status is not as strict as it may first appear since projections of health service and health manpower requirements may be assumed to derive from changes in health status. Thus changes in the amount and type of health services and the amount and types of health manpower needed in a population may be seen as arising from differential changes in the demographic structure of the population and in changing health status (in terms of morbidity, disability and mortality) of subgroups of the population which may be defined by geographic, demographic or socio-economic factors. The computer programs reviewed in the paper are Standard Demographic Models such as MEDDAS or Rapid II, Stochastic Compartment Models such as DIALOG or Prevent and Stochastic Process Models such as MACSPM.

Title: Some Forecasting Techniques (with brief annotations)
Author: T.K. Sundaresan
Source: WHO Geneva: Division of Epidemiological Surveillance and Health Situation and Trend Assessment, Unit of Monitoring, Evaluation and Projection Methodology; 1991
Abstract: During the last three decades attempts have been made to place

forecasting on a more objective footing and supported by quantitative information wherever possible. Several techniques have been developed for this purpose. Most of them require mathematical or statistical skills and involve huge computational labour. However, with the advent of modern computers the application of these techniques in practical situations has become much more feasible.
In this document an attempt has been made to catalogue some of these techniques, with brief explanations of their aim and purpose and some examples of application wherever possible. The following lists a few of the methods included: Trend Extrapolation (mathematical and graphical), Explorative Methods such as Simulation, Delphi, Scenarios or Morphology and Normative methods such as Linear Programming and Decision Trees.

2 Specific Models

2.1 Epidemiology and Diseases Control

Title: Computerized epidemiological model of typhoid fever with age structure and its use in the planning and evaluation of antityphoid immunization and sanitation programmes
Author: B. Cvjetanovic, B. Grab, H. Dixon
Address: Mr H. Dixon, World Health Organization, 1211 Geneva 27, Switzerland
Source: Mathematical Modelling, vol.7, pp.719-744, 1986
Abstract: An epidemiological model of typhoid fever was further developed. Age structure was added to the population dynamics, but non-essential epidemiological classes were eliminated. Thus the dynamic of the disease specific age groups can be studied, and the effect of public health interventions in these groups simulated. The model is based on the natural history of the disease and represents the multistate epidemiological structure. It enables simulation of endemic processes in the various age groups of the population and the effects of control measures such as immunization or sanitation on the natural course of infection in various age strata of the population. The computer program system is given and the article provides all relevant information necessary for the use of the model for public health purposes.

Title: Prospective Evaluation of Onchocerciasis Control
Author: Onchocerciasis Control Programme
Source: WHO, OCP, Ouagadougou, 24 November 1989, Document OCP/B15/7.1/89/3
Abstract: This document deals with a detailed description of the transmission model ONCHOSIM. This model allows the prediction of long term epidemiological trends after interruption of larviciding, of the impact of large scale ivermectin treatment, and of combinations of these control methods. In 1988 some results of preliminary simulations were presented to the EAC, which gave high priority to the further development and application of epidemiological modelling in order to provide the best

possible information on which to base operational decisions. Since then the model has been improved, systematically tested and sensitivity analyses have been undertaken. Early 1989 a start has been made with the utilization of the model in the prospective evaluation of alternative control strategies in the OCP. The present report provides a summary of the main findings obtained to date.

Title: Selection of MDT strategies through epidemiometric modeling.
Author: Lechat-MF; Declercq-EE; Misson-CB; Vellut-CM
Source: Int-J-Lepr-Other-Mycobact-Dis. 1990 Jun; 58(2): 296-301
Abstract: The epidemiometric model of leprosy, built on Polambakkam, India, data, is used to compare the impact on incidence of dapsone and different multidrug therapy (MDT) strategies. The simulations show that generalization of MDT could have a dramatic impact on transmission of the disease. Relapses after MDT, although important from an individual point of view, have a negligible influence on the incidence. Introduction of MDT requires investments that, during the first few years of the program, are much greater than for dapsone monotherapy. These are, however, rapidly absorbed due to the rapidly declining number of new cases, particularly when MDT is not limited to multibacillary cases but is administered to all patients.

Title: Epigenesis theory: a mathematical model relating causal concepts of pathogenesis in individuals to disease patterns in populations.
Author: Koopman-JS; Weed-DL
Source: Am-J-Epidemiol. 1990 Aug; 132(2): 366-90
Abstract: A mathematical modeling approach called epigenesis theory is presented which relates three aspects of pathogenesis to the population distribution of disease. The three aspects of pathogenesis involve how two or more measured variables interact. They are 1) whether the measured variables are related to the same causal action, 2) whether there is only one pathogenic process leading to disease, and 3) whether the measured variables contribute to the same pathogenic process. Epigenesis theory defines the following multivariable relations between two disease causes: 1) "Complementary" causes contribute different causal actions to the sole pathogenic process leading to disease. They have multiplicative relations. 2) "Separate process" causes contribute different causal actions to different pathogenic processes. They have the relations of simple independent action which are slightly less than additive. 3) "Intermediate" causes contribute different causal actions to the same pathogenic process in the presence of additional pathogenic processes where at most one of them may also participate. They have relations somewhere between multiplicative and simple independent actions. 4) "Cooperative-competitive" causes share the same causal action and act within the same pathogenic process. Their relations can change from greater than multiplicative to less than simple independent action at increasing dichotomization points of the measured variables. Epigenesis theory unifies the sufficient-component causes model and the simple independent action model and exceeds either model in the

range of observations it can explain. It is most useful given directly causal measured variables and specific disease outcomes, but it will assist in etiologic investigations of nonspecific outcomes in which new disease classifications are proposed. While it is less useful given surveillance-type variables such as age or sex or outcomes resulting from numerous pathogenic processes such as death, it gains utility as more causal variables are entered into an analysis and as more cut points of continuous complementary, independent, or intermediate variables are distinguished.

Title: The Dynamics of Tetanus Epidemiology and Control in Rural Uttar Pradesh Studied Through Computer Simulation
Author: Monica Sharma
Source: Social Science in Medicine, Vol 8, pp. 303-313, 1984
Abstract: An epidemiological model is constructed for tetanus. The assumptions as well as the steps involved in the construction of the model, are detailed. The impact of alternate immunization strategies to control tetanus in rural Uttar Pradesh, is studied using this model. The quantification of the expected decline in incidence and mortality over 30 years, for different control strategies, provides the health planner with valuable information. It is seen that the incidence of tetanus neonatorum and tetanus in adults, as well as deaths due to tetanus, progressively decreases as the level of coverage is increased. The most marked reduction is sen over the initial period of intervention. Mass immunization of the total population, or of just the females in the reproductive age group, leads to temporary decline in the endemic level. Such models are useful for planning in the health sector in India since, they can be constructed with the limited information available.

Title: Projections of AIDS Morbidity and Mortality in San Francisco
Author: Lemp-GF; Payne-SF; Rutherford-GW; Hessol-NA; Winkelstein-W Jr; Wiley-JA; Moss-AR; Chaisson-RE; Chen-RT; Feigal-DW Jr; et-al
Source: JAMA. 1990 Mar 16; 263(11): 1497-501
Abstract: To develop a model for predicting acquired immunodeficiency syndrome (AIDS) morbidity in San Francisco, Calif, through June 1993, we combined annual human immunodeficiency virus seroconversion rates for homosexual and bisexual men and for heterosexual intravenous drug users with estimates of the cumulative proportion of the population with AIDS by duration of human immunodeficiency virus infection and with estimates of the size of the at-risk populations. We projected AIDS mortality by applying Kaplan-Meier estimates of survival time following diagnosis to the projected number of cases. The median incubation period for AIDS among homosexual and bisexual men infected with the human immunodeficiency virus was estimated to be 11.0 years (mean, 11.8 years; 95% confidence interval, 10.6 to 13.0 years). The model projects 12,349 to 17,022 cumulative cases of AIDS in San Francisco through June 1993, with 9,966 to 12,767 cumulative deaths.

Title: AIDS and HIV in Wisconsin: Projections for the Decade.
Author: Hoxie-NJ; Vergeront-JM; Davis-JP
Source: Wis-Med-J. 1990 Jun; 89(6): 261-6
Abstract: Based on a projection model developed by the Wisconsin AIDS/HIV Program, at the beginning of 1990 there were between 7,143 and 11,957 HIV-infected persons in Wisconsin. During the 1990s the cumulative number of HIV-infected persons in the state may more than double to between 16,471 and 25,932. We project that between 6,329 and 9,489 new cases of acquired immunodeficiency syndrome (AIDS), and between 3,577 and 5,365 AIDS deaths will occur in Wisconsin in next ten years. This is a greater than 13-fold increase in AIDS cases over the 1980s. By the end of the 1990s, the number of persons living with AIDS is projected to be ten-fold greater than the currently estimated number. To make plans for the future, policy makers need to be aware of this expected large increase in HIV-related morbidity and mortality.

Title: Forecasting the Number of AIDS Cases: An Analysis of Two Techniques.
Author: Hellinger-FJ
Source: Inquiry. 1990 Fall; 27(3): 212-24
Abstract: Two methods used to forecast AIDS cases--trend analysis and back calculation--are examined in this paper. I forecast AIDS cases using trend analysis with data on the number of cases reported between January 1984 and March 1990. Forecasts using back calculation methods are based on the assumption that the progression rates from HIV to AIDS slowed in 1988 due to the use of AZT and aerosol pentamidine. With both methods, reasonable models yield widely different forecasts. Analysis also is hampered by a lack of information about the basic determinants of AIDS incidence, changes in the definition of AIDS, under reporting, and uncertainty about the effect of the use of prophylactic drugs. It is not possible to establish confidence limits around forecasts that take into account these sources of biases, and it is important that those who use AIDS forecasts be aware of these uncertainties.

Title: The Health Benefits of Prevention - A Simulation Approach
Author: Louise Gunning-Schepers
Source: Erasmus University Rotterdam (1988)
Abstract: In epidemiology an analysis of the distribution of disease incidence and risk factor prevalence in different populations is used to confirm the hypothesis of a causal relationship between risk factor and disease. The strength of the relationship is often expressed as the ratio of incidence between exposed and non exposed, the Incidence Density Ratio (IDR). The importance of a risk factor for the incidence of a certain disease in a population is usually expressed as the Etiologic Fraction (EF), the proportion of the total incidence of the disease that can be attributed to the prevalence of that risk factor in the population. The EF is sometimes used as an indication of the proportion of incidence that could be prevented by the total elimination of that risk factor in the population. However, since most often prevention will not eliminate but merely reduce

the prevalence of a risk factor on the incidence of a disease, a measure was developed to estimate the impact of a change in prevalence of a risk factor in the incidence of a disease, the Potential Impact Fraction (PIF). It stands for the incidence that is avoided by a preventive intervention as a proportion of the incidence that would have occurred in that population without the intervention.

Prevent estimates the effect of changes in risk factor prevalence in a population in terms of health benefit. It is based on the epidemiologic effect measure the Potential Impact Fraction. To achieve the objectives of the project it has incorporated the following three requirements in the methodology:

- the possibility that one risk factor affects several diseases, and that one disease is affected by several risk factors;
- a time dimension to simulate the reduction in excess risk after cessation of exposure to the risk factor;
- the interaction between the effect of the intervention and the demographic evolution in the population.

The models will stimulate the development, over time, of two populations: one as a result of trends in risk factor prevalence and demography, and the other which incorporates both trends and interventions on risk factors and the demography. Differences between these two populations are the effect of the intervention. In the current version of Prevent all measures of health benefit are based on mortality.

Title: Simulation modeling perspectives of the Bangladesh family planning and female education system.

Author: Teel-JH; Ragade-RK

Source: Behav-Sci. 1984 Jul; 29(3): 145-61

Abstract: A systems dynamics simulation study of the interaction of various social subsystems in the People's Republic of Bangladesh is chosen to address integrated planning concerns. It is concluded that one should not underestimate the potential of noneconomic societal forces: They can have a positive impact on slowing population growth and improving the quality of life. Methodologies included: fuzzy profiles for choosing primary variables; interpretive impact matrices to generate the systems dynamics equations; interactive computer capabilities for purposes other than simulation runs; modeling log file to note modeling assumptions, changes, and redefinitions; and microcomputer portability.

Title: A Model for Health Sector Planning in the Context of Rapid Population Growth

Author: George B. Simmons

Source: Department of Population Planning and International Health, School of Public Health, University of Michigan (1986)

Abstract: Given the scarcity of resources, one central task of planning is to design the appropriate mix and standards of preventive and curative interventions needed to maximize the attainment of health objectives.

Rapid population growth and changes in age distribution also influence the incidence of various diseases. Health planners need to anticipate and plan for health services requirements in the future.

The process of planning for health can be greatly facilitated by the use of quantitative, computer-based models of the health system. These models can be used by planners to explore the possible impacts of a variety of interventions on health. The ability of these models to distinguish between better and worse options and allocations of scarce resources will depend upon the reasonableness of the model specification and the parameters used, but even simple computer models can be an important complement to the other tools of health planners.

Title: A population dynamics simulation model with application to health planning.
Author: Sanders-JL
Source: J-Health-Adm-Educ. 1986 Summer; 4(3): 453-65
Abstract: Despite the increasing emphasis on computers and quantitative methods in health services programs, health services administration students are denied access to many of the most powerful tools of systems analysis, including discrete event simulation, because they lack the necessary background in computer programming, simulation methodology, and stochastic processes. This article presents an approach to the modeling of the growth and decline of population groups and their attributes that can be used by students who do not have the extensive quantitative background required to develop the usual discrete event simulation models. The underlying theory, which is based on the behavior of the expectation process of vector Galton-Watson branching processes, can be explained quite easily. An example is presented that uses an age and sex specific model of population growth to investigate policy questions related to the feasibility of the construction of a long-term care facility for a defined population group. Planning decisions are based on the growth and decline of the numbers of individuals in the various age and sex groups. Extensions of the basic methodology are possible that would include projections of the variance-covariance matrix of the population sizes for each year of the projection process. In addition, the model can be extended to include projections of the impact of infectious and communicable diseases on a defined population group together with the effect of categorical disease screening and control programs. Given the basic data utilized in the model, the implementation of the calculations required by the model can be made on modern microcomputer hardware using any of the standard spreadsheet programs.

Title: Life events, fitness, hardiness, and health: a simultaneous analysis of proposed stress-resistance effects.
Author: Roth-DL; Wiebe-DJ; Fillingim-RB; Shay-KA
Address: Department of Psychology, School of Social and Behavioral Sciences, University of Alabama, Birmingham 35294.
Source: J-Pers-Soc-Psychol. 1989 Jul; 57(1): 136-42
Abstract: The effects of exercise participation, self-perceived fitness level, and dispositional hardiness for promoting stress resistance were examined in a sample of 373 college students. Self-report measures of stressful life experience and recent physical illness were positively correlated, and fitness and hardiness were negatively correlated with illness as expected.

Multiple regression analyses indicated that neither fitness nor hardiness provided a stress-moderator effect because neither was found to significantly interact with stress in the prediction of illness scores. Structural equation analyses suggested that hardiness may affect health indirectly by first influencing either the occurrence or subjective interpretation of stressful life events. No direct effect on health was found for exercise participation, although exercise may reduce illness indirectly by improving fitness. Implications for the multivariate modeling of proposed stress-resistance-enhancing effects are discussed.

Title: Poisson regression modeling of temporal variation in incidence of childhood insulin-dependent diabetes mellitus in Allegheny County, Pennsylvania, and Wielkopolska, Poland, 1970-1985.

Author: Rewers-M; Stone-RA; LaPorte-RE; Drash-AL; Becker-DJ; Walczak-M; Kuller-LH

Address: Diabetes Research Center, Pittsburgh, PA 15213.

Source: Am-J-Epidemiol. 1989 Mar; 129(3): 569-81

Abstract: Contradictory observations have accumulated regarding a secular trend and/or an epidemic pattern in the incidence of insulin-dependent diabetes mellitus. In this study, insulin-dependent diabetes mellitus incidence below age 15 years was examined in Allegheny County, Pennsylvania, and in Wielkopolska, Poland, two areas diverse in terms of their geography and average risk for this disease. Numerator data were extracted from individual patient records, and annual denominator data were available for the years 1970-1985. Poisson regression models were used to disentangle the contributions of country, race, sex, age, period, and cohort effects to the observed variation in incidence. Poles and Allegheny County nonwhites were at greatly and moderately reduced risk, respectively, relative to Allegheny County whites. An increase in risk with age was significant and proportional in all three groups. There was significant time variability in Wielkopolska, where an epidemic began in 1982 and continued through 1985. This was a period rather than a cohort phenomenon and was a result of a recent outbreak of the disease rather than a long-term trend. In Allegheny County, changes in risk over the 16-year period were insignificant, although incidence doubled among whites aged 0-9 years during 1982-1983. The Poisson regression modeling provided a quantification and formal comparison of determinants of the incidence of insulin-dependent diabetes mellitus.

Title: Vitamin A Cost-Effectiveness Model

Author: Robert N. Grosse

Source: International Journal of Health Planning and Management, Vol 3, 225-244 (1988)

Abstract: To assist in the selection of a preferable vitamin A deficiency control policy, a model has been developed to organize information on program costs and program-related effects. The model was designed to compare three approaches: (1) diet modification; (2) fortification of processed foods; and (3) periodic large doses. Health effects projected are rates of specific eye pathologies associated with vitamin A deficiency (xerophthalmia), and mortalities within age cohorts. Effectiveness is

calculated as a function of coverage, biological efficacy, and incidence of vitamin A deficiency. The model was applied to data from the Province of West Java in Indonesia. The results of this application suggest that funding level considerations are an important factor in selecting a preferred control strategy. In addition to determining the relative resource requirements of alternative interventions aimed at reducing the morbidity and mortality effects of vitamin A deficiencies, the model, using marginal cost and marginal effectiveness information, can serve as a guide to the most efficient allocation of resources for each type of intervention.

Title: A Demographic Projection Model for Development Planning - for the IBM PC Microcomputer

Author: The Futures Group

Source: The Futures Group (1986)

Abstract: The Demographic Projection Model (DemProj) created by The Futures Group is a full-featured population projection program. It can be used to project the population of an entire country under different assumptions about the future course of birth, death and migration rates. Complete output is provided on the future number of people in the population by age and sex. Summary demographic indicators are also calculated and displayed.

The program can also be used to project the urban and rural populations. As a special feature, it can also project the size of special areas or regions. This feature will be useful in projecting the size of areas of special interest such as particular cities or towns or service areas for health or educational facilities. These area projections supply full detail on the age and sex composition of the population.

The DemProj model will be useful for preparing estimates of the future size of populations that will need to be served by development projects. It can also be used to prepare the demographic inputs to special projection models that have been prepared by The Futures Group. These include the EdSim education simulation model, the Health Simulation Model and the Manpower Planning Model.

DemProj uses the cohort component technique of population projections. In this method each cohort (group of people born during the same time period) is followed through time. The program divides the total population into males and females and 17 age groups. The first 16 age groups contain 5 years each. They range from ages 0-4, 5-9, 10-14 etc., up to 75-79. The final age group contains all people aged 80 and over.

The projection methodology is the same as that employed by the United Nations.

Title: Senegal Rapid II Presentation Model

Author: Bachir Ben Geloune, Abdel Kader Faye

Source: School of Public Health, University of Michigan (1986)

Abstract: The model has been developed by Senegalese planners under the coordination of the staff of CONAPOP (National Population Commission) in Dakar, Senegal, under a subcontract with the Futures Group, Washington.

The model was prepared entirely within a Lotus 1-2-3 spreadsheet, using the Lotus command language to create a macro or automated sequence of commands for an interactive presentation session. The command language of Release 2 of Lotus 1-2-3 is employed.

The GDP projection presentation model yields a large number of tables and graphs. The topics thus represented include historical series on economic growth in Senegal, demographic projections, urbanization, and projections of value added, GDP, and GDP per capita. The tables and graphs can be printed as well.

The beginning point is a set of stored demographic projection scenarios, calculated using the RAPID Demographic Projection program, with assumptions chosen by staff of the National Census Bureau and CONAPOP. The demographic scenarios are then fed into six separate modules of the economic implications of population change. These six sectoral modules relate population change to changes in Gross Domestic Product and sectoral valued added, employment by sector, fuelwood consumption, consumption and production of cereals, educational enrollments, and demand for health care professionals. A seventh module calculates the contraceptive prevalence rates needed to achieve targeted fertility declines, using Bongaarts target model.

In addition to three scenarios regarding the size of the national population, it was decided to establish three alternate scenarios for rates of urbanization. The existing data for trends in urbanization was fitted by means of logistic regression, and the coefficients were used to project the percent urban for the projection period.

Title: The dynamics of HIV spread: a computer simulation model.
Author: Leslie-WD; Brunham-RC
Source: Comput-Biomed-Res. 1990 Aug; 23(4): 380-401
Abstract: Mathematical modeling of the AIDS pandemic has been limited by the difficulty of satisfactorily representing the marked behavioral heterogeneity that characterizes the various populations at risk. We propose an approach which models the spread of infection as a discrete-event simulation using SIMSCRIPT, a powerful simulation language. The program developed provides sufficient flexibility to adequately represent and study a wide range of risk-group dynamics. Using this tool we have verified the May-Anderson prediction relating contact rate heterogeneity to the rate of HIV spread. We have also been able to assess the sensitivity of the model to the particular choice of distribution for contact rates, disease stage durations, and intercontact intervals. It is thought that this approach will permit the empirical testing of hypotheses which do not lend themselves to a purely mathematical treatment.

Title: Forecasting mortality: a parameterized time series approach.
Author: McNown-R; Rogers-A
Address: Population Program, University of Colorado, Boulder 80309.
Source: Demography. 1989 Nov; 26(4): 645-60
Abstract: This article links parameterized model mortality schedules with time series methods to develop forecasts of U.S. mortality to the year 2000. The use of model mortality schedules permits a relatively concise representation of

the history of mortality by age and sex from 1900 to 1985, and the use of modern time series methods to extend this history forward to the end of this century allows for a flexible modeling of trend and the accommodation of changes in long-run mortality patterns. This pilot study demonstrates that the proposed procedure produces medium-range forecasts of mortality that meet the standard tests of accuracy in forecast evaluation and that are sensible when evaluated against the comparable forecasts produced by the Social Security Administration.

2.2 Management of Care

Title: DRG [Diagnostic Related Groups] Resource Utilization Modelling System
Author: Voratas Kachitvichyanukul, Tzvi Raz, Jim Lee, Edith Paul
Source: Simulation in Health Care Delivery System, Proceedings of the Conference on Simulation in Health Care Delivery Systems, 2-4 February 1984, San Diego, California; Edited by Charles R. Standridge; a Publication of the Society for Computer Simulation (Simulation Councils, Inc.), La Jolla, California, 1984
Abstract: The effective analysis and planning of hospital operations require significant effort. The DRG Resource Utilization Modelling System (DRUMS) reduces that effort to a manageable level. DRUMS is a fully interactive modelling package designed and written to allow hospital managers to evaluate the impact of various DRG mixes in the utilization of resources and the resulting costs and profits. The system configuration and the software structure are presented along some example output reports.

Title: Decision-modeling methods used to design decision support systems for staffing.
Author: Nutt-PC
Source: Med-Care. 1984 Nov; 22(11): 1002-13
Abstract: This paper explores the merits of two methods that extract the decision models of experts to serve as a decision support mechanism for staffing. One method has experts make judgments about hypothetical cases and the other has experts decompose the decision into criteria weighting and scaling. Staffing models were developed for each method using nurses who work in neonatology wards in two large hospitals. The four decision models were used to predict the demands for nursing time in both hospitals, which were compared with an ex post facto assessment of needs to validate the models. To measure transportability, the author used the model developed in one site to predict nursing hours for the other site. Both methods were found to be acceptable when applied at the site where they were developed. However, the ability to transport either model was negligible, suggesting that universal protocols for staffing do not exist.

Title: A decision support model and analysis for hospital administrators when choosing future strategies of their hospitals.
Author: Sekita-Y; Omichi-M
Address: School of Medicine, Tohoku University, Sendai, Japan.
Source: Jpn-Hosp. 1990 Jul; 9: 31-6
Abstract: How to allocate a hospital's finite resources to health care is an extremely

important problem for hospital management. This paper shows what kind of business strategies a given hospital should consider, and present a model to support such decision making. From the model, a hospital can decide how much to emphasize different tasks in order to set a given direction for the future. We used nonlinear discriminant functions to derive a decision support model, based on findings from 831 hospital directors. This model provides a probabilistic basis for deciding how much a given hospital should emphasize any of a number of different strategies.

Title: Modeling emergency department operations using advanced computer simulation systems.
Author: Saunders-CE; Makens-PK; Leblanc-LJ
Source: Ann-Emerg-Med. 1989 Feb; 18(2): 134-40
Abstract: We developed a computer simulation model of emergency department operations using simulation software. This model uses multiple levels of preemptive patient priority; assigns each patient to an individual nurse and physician; incorporates all standard tests, procedures, and consultations; and allows patient service processes to proceed simultaneously, sequentially, repetitively, or a combination of these. Selected input data, including the number of physicians, nurses, and treatment beds, and the blood test turnaround time, then were varied systematically to determine their simulated effect on patient throughput time, selected queue sizes, and rates of resource utilization. Patient throughput time varied directly with laboratory service times and inversely with the number of physician or nurse servers. Resource utilization rates varied inversely with resource availability, and patient waiting time and patient throughput time varied indirectly with the level of patient acuity. The simulation can be animated on a computer monitor, showing simulated patients, specimens, and staff members moving throughout the ED. Computer simulation is a potentially useful tool that can help predict the results of changes in the ED system without actually altering it and may have implications for planning, optimizing resources, and improving the efficiency and quality of care.

Title: Capital Budgeting in Hospital Management using the Analytic Hierarchy Process
Author: Tarimcilar-MM, Khaksari-SZ
Source: Socio-Econ. Plann. Sci. 1991; 25(1): 27-34
Abstract: The focus of this paper is on the development of a model to evaluate alternative solutions to capital budgeting problems within a health care institution. In recent years the health care industry has been experiencing change to a degree unprecedented since the inception of the Medicare program. With traditional in-hospital care on the decline, hospitals are being forced to compete for business. They must identify within their own systems feasible alternatives for dealing with these changes and then determine which ones will best accomplish the goals of the organization. The paper describes a multicriteria decision making tool that helps arrange the possible alternatives in hierarchical order given the priorities of relevant decision makers. The procedure is flexible enough to be updated for the realities of any health care institution.

Title: Understanding economic modeling aids in decision making.
Author: Coddington-DC; Keen-DJ; Steiker-AB
Source: Healthc-Financ-Manage. 1988 Oct; 42(10): 54, 56, 58 passim
Abstract: With the problems some hospitals are facing in raising capital, the importance of careful economic analyses increases. Four economic models, the demand model, economic feasibility model, economic impact model, and econometric model, can all be used by the healthcare industry to perform a thorough analysis. By doing economic analyses, hospitals will be able to more effectively allocate scarce financial resources and identify potential returns and risks associated with investments.

Title: Computer modeling of emergency medical system performance.
Author: Valenzuela-TD; Goldberg-J; Keeley-KT; Criss-EA
Source: Ann-Emerg-Med. 1990 Aug; 19(8): 898-901
Abstract: Emergency medical services (EMS) system managers face difficult problems when determining the need for system expansion and unit deployment. Information relevant to the decision is often limited and frequently not in a usable format. This lack of usable information often results in decisions that create less-than-optimal EMS systems. A constant search for greater efficiency prompted the development of a computer simulation model to analyze the current EMS system operated by the Tucson Fire Department and to provide statistical information on the effects of potential vehicle base locations on system performance. The simulation model generates data that reflect a variety of parameters necessary in base location analysis. Included in the performance statistics for each unit and for the entire system are indicators of unit use rates, minimum and maximum response times, and proportion of calls reached within the critical response time of eight minutes or less. The model has been carefully validated and used in unit redeployment and unit activation in Tucson, Arizona.

Title: An application of capture-recapture methods to the estimation of completeness of cancer registration.
Author: Robles-SC; Marrett-LD; Clarke-EA; Risch-HA
Address: Division of Epidemiology and Statistics, Ontario Cancer Treatment and Research Foundation, Canada.
Source: J-Clin-Epidemiol. 1988; 41(5): 495-501
Abstract: Completeness of cancer registration has not been consistently ascertained across different registries. This report describes how capture-recapture methods have been used to estimate completeness at the Ontario Cancer Registry. The method was applied in two fashions; first, using three data sources in a modeling approach: and second, using two data sources and standard, simple capture-recapture methods. The modeling approach is more flexible, since several variables that influence cancer registration can be considered and can be used to identify reporting patterns of different data sources. In the present analysis, estimates of completeness of the registry as a whole were remarkably similar using either two or three data sources, and site-specific comparisons differed by at most 7%. Because of the advantages of capture-recapture methods-estimation of level of completeness, possible comparability of estimates across different

registries, and versatility to consider other determinants of cancer registration-a plea for greater use of these methods in cancer registration is made.

2.3 Manpower Planning and Management

Title: Estimates of Physician Requirements for 1990 for the Specialties of Neurology, Anesthesiology, Nuclear Medicine, Pathology, Physical Medicine and Rehabilitation, and Radiology. A Further Application of the GMENAC Methodology.

Author: Bowman-MA; Katzoff-JM; Garrison-LP Jr; Wills-J

Source: JAMA. 1983 Nov 18; 250(19): 2623-7

Abstract: The Graduate Medical Education National Advisory Committee (GMENAC) adjusted needs-based model for determining physician requirements was applied to the specialties of anesthesiology, neurology, nuclear medicine, pathology, physical medicine and rehabilitation, and radiology, which had not been completed at the time of the original GMENAC final report. Physical medicine and rehabilitation continues to be projected as a shortage specialty; anesthesiology is in near balance. Neurology and pathology are no longer projected to be specialties of oversupply, but rather to be in near balance. Diagnostic radiology continues to be projected as a specialty of oversupply; therapeutic radiology is projected to be in near balance, as is nuclear medicine. The GMENAC aggregate-requirements estimates are thus revised upward from 466,000 to 473,000 full-time equivalent physicians for 1990, reducing the projected surplus from 15.0% to 13.3%.

Title: Future Requirements For and Supply Of Ophthalmologists. What do the Forecasts Show?

Author: Trobe-JD; Kilpatrick-KE

Source: Arch-Ophthalmol. 1982 Jan; 100(1): 61-6

Abstract: Forecasts of the requirements for and supply of ophthalmologists in 1990 have produced conflicting results because of varying assumptions about the future utilization of eye care services, incidence and prevalence of ophthalmic disease, physician productivity, and availability of residency training positions. A typical "utilization-based" models, founded on present consumer behavior, predicts a substantial 1990 surplus of ophthalmologists at current rates of residency training. Two "need-based" models, founded on ideal rather than actual use, reach different conclusions because of varying use of a fragile data base and the need to rely heavily on the subjective judgment of experts with regard to norms of care. The 1980 Graduate Medical Educational National Advisory Committee forecasted a surplus, while the 1978 American Academy of Ophthalmology predicted a deficit. Utilization-based models may slightly underestimate future ophthalmologist requirements. However, analysis of the factors that will influence future use suggests that need-based models are likely to overestimate the requirements. It is risky to accept the need-based model projections because of the high cost of a surplus, which include not only the expenses of training unneeded ophthalmologists but also the cost of their decreased exposure to disease and of declining physician morale, acumen, and thresholds for surgical procedures. Because free market

mechanisms are ineffective in governing the supply of health providers, it will be necessary for the profession itself to review the current and projected supply and to set limits on the number of persons in training.

Title: A Comparison of the Requirements for Primary Care Physicians in HMOs with Projections made by the GMENAC.
Author: Steinwachs-DM; Weiner-JP; Shapiro-S; Batalden-P; Coltin-K; Wasserman-F
Source: N-Engl-J-Med. 1986 Jan 23; 314(4): 217-22
Abstract: We compared staffing patterns in primary care specialties in three large health maintenance organizations (HMOs) with the national requirements for physicians in 1990 projected by the Graduate Medical Education National Advisory Committee (GMENAC). The HMOs varied in their use of non-physician providers, family practice specialists, and subspecialists in internal medicine. Nevertheless, projections based on the average experience of these HMOs suggest that 20 percent fewer primary care physicians for children and 50 percent fewer primary care physicians for adults will be needed to meet national primary care needs in 1990 than projected by the GMENAC. As enrollment in HMOs continues to grow, their impact on national requirements for medical personnel will increase. The variety of staffing patterns found among HMOs operating in highly competitive markets suggests the importance of considering alternative configurations for meeting national requirements for primary care.

Title: Manpower Planning for Physical Medicine and Rehabilitation: Comment on GMENAC Process.
Author: Honet-JC
Source: Arch-Phys-Med-Rehabil. 1984 Jul; 65(7): 404-7
Abstract: Although physical medicine and rehabilitation (PM&R) was not analyzed by the Graduate Medical Education National Advisory Committee (GMENAC) Delphi Adjusted Needs Based Modeling process completed in 1980, a provisional manpower requirement estimate of 3,200 physiatrists was included in the final report. In late 1981 and early 1982, the GMENAC model was used and an official 1990 estimate of 4,060 physiatrists needed, with only 2,400 physiatrists available, was determined. This report summarizes the initial correspondence and the assessment study methods for PM&R utilized to attain these estimates. Considerable variability of the numbers determined by the Delphi Panel is apparent. These estimates have been accepted by the Office of Graduate Medical Education and although no official action has ensued, the results are on record for future manpower planning and may be a factor in the current interest of medical students in the specialty of PM&R.

Title: A Disaggregation Model of a Flexible Nurse Scheduling Support System
Author: Ozkarahan I
Source: Socio-Econ. Plann. Sci. 1991; 25(1): 9-26
Abstract: A nurse scheduling support system is developed in which the demand profile and nurses' preferences are input to an expert-like capability designed to formulate linear and/or goal programming representation of

the problem. Solutions of the alternative optimization models of this decision support system are evaluated. An assignment model for disaggregating the optimum work patterns of individual nurses based on their desires and compatibilities is discussed in detail.

2.4 Utilization and Demand for Care

Title: Self-care within a model for demand for medical care.
Author: Bentzen-N; Christiansen-T; Pedersen-KM
Source: Soc-Sci-Med. 1989; 29(2): 185-93
Abstract: Self-care is interpreted from a health economic point of view. Various approaches are presented. It is stressed that the decision-oriented approach used by other health service researchers is an integral part of the economic approach to the topic as is the idea of a continuum of care, from self-care to professional care. A new approach is taken to the modeling of self-care, in that self-care becomes part of a four-part demand for care model. This makes it possible to model the demand for care for three different groups separately: 1--persons with zero episodes; 2--persons with pure illness episodes and illness episodes with self-care; 3--persons with episodes involving professional care or professional care combined with self-care. Another contribution is due to the so-called episodic approach to the demand for care. The natural counting units are illness and treatment episodes, i.e. instead of counting for instance number of times a general practitioner is consulted we ought to count the number of episodes involving professional care, self-care or both types of care. The episodic approach seems to be well suited for work with self-care. The empirical part is based on a unique Danish panel study using health diaries returned weekly. Data from 27 of the 52 reporting weeks are used, involving more than 14,000 episodes distributed across about 2800 persons belonging to about 1000 households. The use of health diaries seems to be very well suited to the study of self-care in that less salient events and activities than professional care are picked up far better in prospective health diary studies than in retrospective questionnaire based surveys. Descriptive and regression (logistic and ordinary) results are presented.

Title: Models for forecasting hospital bed requirements in the acute sector.
Author: Farmer-RD; Emami-J
Address: Department of Community Medicine, Charing Cross and Westminster Medical School, London.
Source: J-Epidemiol-Community-Health. 1990 Dec; 44(4): 307-12
Abstract: STUDY OBJECTIVE--The aim was to evaluate the current approach to forecasting hospital bed requirements. DESIGN--The study was a time series and regression analysis. The time series for mean duration of stay for general surgery in the age group 15-44 years (1969-1982) was used in the evaluation of different methods of forecasting future values of mean duration of stay and its subsequent use in the formation of hospital bed requirements. RESULTS--It has been suggested that the simple trend fitting approach suffers from model specification error and imposes unjustified restrictions on the data. Time series approach (Box-Jenkins

method) was shown to be a more appropriate way of modelling the data. CONCLUSION--The simple trend fitting approach is inferior to the time series approach in modelling hospital bed requirements.

Title: A framework for modeling the consumption of health services by the rural elderly.
Author: Joseph-AE; Cloutier-DS
Source: Soc-Sci-Med. 1990; 30(1): 45-52
Abstract: This paper reports on an ongoing research program which seeks to assess the implications of population aging for housing, services and transportation in rural communities in the Province of Ontario. Specifically, the focus is on the modeling of health and social service consumption by elderly (over 65) persons. Following a review of the literature on service provision to senior citizens in Ontario, a modeling framework conceptualizing the process of service utilization at both the aggregate (user and nonuser characteristics) and individual (decision-making) levels is introduced. Data on use of community support services drawn from a survey of elderly residents in two communities in Grey County, Ontario (Meaford, population 4380 in 1986, and Markdale, population 1226 in 1986) are used to illustrate the general features of the modeling framework. Particular attention is paid to the ability of the modeling framework to yield insights into the origins of notable variations in service use rates between men and women. Overall, the results are taken to be supportive of the usefulness of the modeling framework as a template for guiding empirical analysis of service utilization patterns. At the same time the case study testifies to the complex and dynamic nature of service provision issues in rural communities. The challenge of providing services effectively to an elderly rural population located in scattered villages and small towns will continue to tax the imagination and resources of responsible agencies.

Title: Stochastic modeling of consumer preferences for health care institutions.
Author: Malhotra-NK
Source: J-Health-Care-Mark. 1983 Fall; 3(4): 18-26
Abstract: This paper proposes a stochastic procedure for modeling consumer preferences via LOGIT analysis. First, a simple, non-technical exposition of the use of a stochastic approach in health care marketing is presented. Second, a study illustrating the application of the LOGIT model in assessing consumer preferences for hospitals is given. The paper concludes with several implications of the proposed approach.

Title: Predicting the effect of hospital closure on hospital utilization patterns.
Author: McLafferty-S
Address: Department of Geology and Geography, Hunter College, CUNY, NY 10021.
Source: Soc-Sci-Med. 1988; 27(3): 255-62
Abstract: Geographic patterns of hospital utilization were analyzed before and after the closure of Sydenham hospital in New York City. The purpose was to determine the accuracy with which hospital utilization patterns after

closure could be predicted using standard spatial interaction modeling procedures. Gravity models were calibrated to represent travel to hospitals before and after closure for patients residing in Sydenham's primary service area. Using three variables, hospital size, distance and type, the models accurately described utilization patterns in each year. The distance parameter, however, changed substantially between the 2 years. In addition large errors were observed when the model calibrated before closure was used to predict utilization patterns afterward. The geographic distribution and likely causes of errors were analyzed, along with their implications for spatial modeling efforts.

2.5 Health Economics and Financing

Title: Econometric models and the study of the economic effects of social security
Author: John C. Hambor
Source: Social Security Bulletin, October 1984, vol.47, No.10, pp.3-8
Abstract: The article provides a discussion of previously published research on the use of econometric models in the study of the economic effects of social security. It illustrates the role of econometric model building by focussing on three major applications: forecasting, policy stimulation, and hypothesis testing. Three macroeconomic examples show that the development and use of such models puts the focus of the analysis on the underlying economic structure. These examples are: a program-specific model of the social security system, a large scale model of the U.S. economy and a single equation analysis of a specific issue.

Title: Simulation model on macroeconomics and health
Author: Guy Carrin
Address: World Health Organization, 1211 Geneva 27, Switzerland
Source: Unpublished WHO document, September 15, 1990
Abstract: The model presented in this paper is to assist policy makers in health, planning and finance sectors 1) in assesssing the impact of the macroeconomy on the public sector; 2) in analyzing the consequences of decisions concerning the size of government expenditures and its allocation. The policy maker can use this model as a complementary tool for modifying certain decisions at an early stage.
The model is composed of six blocks of equations: 1. basic economic aggregates, including the balance of payment; 2. general government finance; 3. the government health sector; 4. households' demand for government health care; 5. health status indicators; 6. demography.

Title: Linear programming models for cost reimbursement.
Author: Diehr-G; Tamura-H
Address: Department of Management Science, Graduate School of Business Administration, University of Washington, Seattle 98195.
Source: Health-Serv-Res. 1989 Aug; 24(3): 329-47
Abstract: Tamura, Lauer, and Sanborn (1985) reported a multiple regression approach to the problem of determining a cost reimbursement

(rate-setting) formula for facilities providing long-term care (nursing homes). In this article we propose an alternative approach to this problem, using an absolute-error criterion instead of the least-squares criterion used in regression, with a variety of side constraints incorporated in the derivation of the formula. The mathematical tool for implementation of this approach is linear programming (LP). The article begins with a discussion of the desirable characteristics of a rate-setting formula. The development of a formula with these properties can be easily achieved, in terms of modeling as well as computation, using LP. Specifically, LP provides an efficient computational algorithm to minimize absolute error deviation, thus protecting rates from the effects of unusual observations in the data base. LP also offers modeling flexibility to impose a variety of policy controls. These features are not readily available if a least-squares criterion is used. Examples based on actual data are used to illustrate alternative LP models for rate setting.

Title: Financial modeling for hospital materials managers. Part I.
Author: Green-DL
Source: Hosp-Mater-Manage. 1986 Sep; 11(9): 7-9
Abstract: Beginning in this issue, HMM Editorial Board member Dennis Green will explore five types of financial analysis materials managers are increasingly expected to perform. By the end of this series, HMM readers equipped with a personal computer and/or a financial calculator will have learned to make the following types of financial decisions: Whether to take advantage of a "sale"; Whether to make or buy; How to analyze the "reagent rental" alternative to purchase: How to extrapolate a series of cashflows in present value; and How to create negotiation models for cash acquisitions. As always, HMM welcomes your comments and suggestions.

Title: Financial modeling for hospital materials managers.
Author: Green-DL
Source: Hosp-Mater-Manage. 1986 Dec; 11(12): 9-13
Abstract: In this issue, HMM Editorial Board member Dennis Green concludes his discussion of five types of financial analysis materials managers are increasingly expected to perform. The final two models, extrapolated cash flow and negotiation models are best run with a personal computer. These models often have many variables and/or time periods, which frequently change as terms become clarified and negotiated. With a computer, recalculations are simplified.

Title: Financial modeling/case-mix analysis.
Author: Heck-S; Esmond-T
Source: Comput-Healthc. 1983 Jun; 4(6): 50-1, 54
Abstract: The authors describe a case mix system developed by users which goes beyond DRG requirements to respond to management's clinical/financial data needs for marketing, planning, budgeting and financial analysis as well as reimbursement. Lessons learned in development of the system and the clinical/financial base will be helpful to those currently contemplating the implementation of such a system or evaluating available software.

Title: Modeling budgetary strategies in health policy, East and West.
Author: Welsh-WA
Source: J-Health-Polit-Policy-Law. 1983 Fall; 8(3): 519-53
Abstract: This essay has sought to develop a rationale for new approach to the formal modeling of intergovernmental budgetary relations. The focus has been on health care budgeting, and on evidence from centrally-planned systems in Eastern Europe. But it has been argued that the modeling strategy advanced here will have applicability across policy areas, and across types of political and economic systems. The description of developments in human service provision emphasized the growing complexity of policy activity along both vertical and horizontal dimensions, and the accompanying increase in competition and in strategic thinking as central elements of policy activity generally, and of intergovernmental budgetary relations specifically. It has been argued that these developments are observable not only in Western pluralist systems--where the adumbration of evidence makes it increasingly difficult to take exception to these generalizations--but also in highly-structured systems such as the communist-governed systems of Eastern Europe. The possibility that certain elements of human service policy activity are becoming increasingly similar across ideologically and structurally different system types has numerous significant implications worth exploring. The next step will be the testing of the full set of linear systems theory models with data from Eastern Europe. If these tests are encouraging, important methodological implications for the modeling of budgetary activity would seem to follow.

Title: Modeling the effect of insurance on health expenditures in the People's Republic of China.
Author: Cretin-S; Duan-NH; Williams-AP Jr; Gu-XY; Shi-YQ
Address: RAND Corporation, Santa Monica, CA 90406-2138.
Source: Health-Serv-Res. 1990 Oct; 25(4): 667-85
Abstract: A pilot study was undertaken in two rural counties in Sichuan Province to determine the feasibility of offering health insurance to peasant families. Models of per capital inpatient and outpatient health care expenditures were developed using self-reported utilization from a survey of 880 households, supplemented by cost and utilization data from the providers in the counties. Expenditures at a facility were modeled as a function of level of insurance in three parts: (1) as the product of the probability of any use, (2) the expected number of visits given any use, and (3) the cost per visit at the facility. Output from the model for representative insurance plans is presented.

Title: National Forecasts of the Medical Care Costs of AIDS: 1988-1992.
Author: Hellinger-FJ
Source: Inquiry. 1988 Winter; 25(4): 469-84
Abstract: Two statistical extrapolation models and data on the number of AIDS cases reported between January 1984 and June 1988 yield projections on the future numbers of AIDS cases which are considerably higher than those of earlier projections, while analysis of the lifetime cost of treating

an AIDS patient in 1988 dollars yields estimates lower than most previous estimates. Based on an estimate of $60,000 per patient holding between 1988 and 1992, the analysis forecasts the cumulative lifetime medical care costs of treating all AIDS patients diagnosed with AIDS to be about $2.6 billion in 1988, $3.5 billion in 1989, $4.7 billion in 1990, $6.0 billion in 1991, and $7.5 billion in 1992.

Title: AIDS cost modeling in the U.S.: a pragmatic approach.
Author: Bilheimer-L
Source: Health-Policy. 1989; 11(2): 147-68
Abstract: Sophisticated modeling of the economic impact of AIDS remains a future goal rather than a present reality due to a lack of data. However, policy makers with responsibility for implementing AIDS-related programs have an immediate need for estimates of service utilization and costs. In this paper we describe a microcomputer-based planning model which is structured to reflect the 'epidemic of epidemics' nature of AIDS. In the process of constructing this model, deficiencies in existing data sources have become evident. The second part of the paper describes research issues and priorities for improving data used to estimate the cost of AIDS.

Title: Econometric issues in modeling the costs of AIDS.
Author: Hay-JW
Source: Health-Policy. 1989; 11(2): 125-45
Abstract: The goals of AIDS or HIV econometric modeling efforts are: (i) to evaluate or project the costs-of-illness to the individual and to society; and (ii) to examine the efficiency and cost-effectiveness of medical and social services provided to patients. Most of the standard theoretical and statistical approaches are not applicable because of the scarcity, incompleteness and non-representative nature of available data. This paper discusses specific methodological approaches concerning AIDS and HIV epidemiology, medical cost estimation techniques, evaluation of the cost-effectiveness of social support programs and valuation of human life. The epidemiologic projection approach--a simplified 'back calculation' method--suggests that the number of Americans infected with the AIDS virus in 1987-88 was likely to be between 500,000 and 800,000. This estimate is between 2 and 3 times lower than the U.S. Centers for Disease Control estimates. Methods for estimating both the direct and indirect costs of illness are described.

Title: Resource Allocation Models and Health Service Systems: An Exploration
Author: A.R. Taket
Source: Department of Epidemiology & Medical Statistics, London Hospital Medical College, University of London (1990)
Abstract: The paper is structured in three main sections. As a necessary preliminary, the first section considers the types of resource allocation questions encountered in the health services, in terms of the different situations in which models might be useful, and identifies a taxonomy or classification of "problem areas"; the section concludes by indicating which of these have actually been explored in theory and which in practice (i.e.

in terms of actual application to real world health systems). The second section then analyses factors affecting the choice of appropriate/suitable modelling approaches for particular problem areas. In a third section a series of examples is taken, which relate to particular problem areas and/or particular resource allocation modelling approaches, and these are examined to explore potentially useful avenues for further development.

Title: Resource Allocation Model for Public Health Planning
Author: Martin S. Feldstein, M.A. Piot, and T.K. Sundaresan
Source: Bulletin of WHO, Supplement, Vol 48, 1973
Abstract: Public health administrators are constantly faced with the need to decide on strategies that will ensure the most rational allocation of scarce resources. A precise evaluation of the costs and benefits of different courses of action is therefore essential. Unfortunately, the concepts underlying cost/benefit analysis in the health sector are highly complex. This study describes the basic conceptual scheme for formulating the health sector planning problem within the linear programming framework. This has been applied to the allocation of resources in a tuberculosis controle programme. The nature of the allocation model suggests the application of mathematical programming techniques to arrive at the optimum level of intensity of activities. If the resource requirements of each activity and the resulting benefits are directly proportional to the level at which such activity operates, the allocation problem can be translated into one of general linear programming. The paper presents the mathematical formulation of the allocation model and the details of the computations.

Title: Estimating Medical Industry Impacts on a Regional Economy.
Author: Lichty-RW; Jesswein-WA; McMillan-DJ
Source: Med-Care. 1986 Apr; 24(4): 350-62
Abstract: The authors demonstrate a large-scale, computerized simulation model to estimate the economic impacts of the regional health services industry on a seven-county region in Northeast Minnesota, known as the Arrowhead Region. The model, known as SIMLAbstract, was developed at the University of Minnesota. SIMLAbstract is designed to simulate the economic performance of a subnational region. Three scenarios were developed: one to illustrate a regional economy functioning normally, one to show how the area's economy would operate in the absence of its entire health services industry, and one to show the regional economic impacts of the closing of a single major hospital within the region. The first two scenarios were compared, with the differences between them representing the impact estimates for the region. The findings give a graphic demonstration of how vitally important health services are to the region. Without the health sector, the region's total gross output for all industries is estimated to fall by more than $1 billion by 1990. A comparison of the first and third scenarios demonstrates the sensitivity of SIMLAbstract to smaller but still significant economic dislocations, such as the closing of a single major health care facility.

Title: A Methodological Note on Location-Allocation Models
Author: Scarpacci-JL
Source: American Journal of Public Health. 1984; 74(10): 1155-7
Abstract: Location-allocation methodologies seek to locate one or more health facilities or services in the most desirable place with the use of heuristic or optimization techniques. Heuristic and optimization techniques cannot be used when: 1) problems are too complex and require expensive computer time, 2) techniques require inaccessible data, 3) problem cannot be expressed as linear equations. It is argued that simpler and alternative approaches to problem solving should be considered. This methodological note presents such an alternative approach to allocating a health service or facility when standard optimization or heuristic techniques are inappropriate. Major advantages of this method are its computational ease and independence from a single technique.

Title: A Health Development Model Application to Rural Java
Author: R. Grosse
Source: School of Public Health, University of Michigan
Abstract: Limited resources and political pressures to improve health in developing countries has created a need for improved planning of health systems. This study describes how a health development model was designed for application in rural Indonesia to assist policy makers in the allocation of resources among health programs. The model uses a systems approach to compare alternative programs of prevention and medical care organization. A disease profile of the Indonesian population was specified in terms of disease incidence and utilization of services. Costs and program effectiveness parameters were developed for each alternative under consideration. Given a fixed per capita budget, alternatives were evaluated in terms of their ability to reduce disability or death.

Through the model computations, it was determined that once each administrative unit was covered by a health center, village health workers and immunization were least expensive in lowering mortality rates and sanitation in lowering disability rates in Indonesia.

The results of the sensitivity analysis showed that the ranking of alternatives were most sensitive to uncertainties in cost and effectiveness estimates whereas changes in attack, case fatality, and utilization rates had much less influence. From these results, research priorities lie in improving the model through further cost analysis and program-specific effectiveness studies.

Title: Cost-Effectiveness Program Model Users Guide
Author: Department of Population and International Health, School of Public Health, The University of Michigan
Source: As above, (1989)
Abstract: The Computerized Cost-Effectiveness Model is a generic cost-effectiveness model written in a computer program called Dbase III+. It is generic in that it may be applied to any region, and will evaluate the effectiveness of any number of public health investments. The model serves to facilitate the development of a disease profile for a specified country or area by

combining the incidence of diseases, case fatality rate, and health service utilization by age for a set of diseases affecting the morbidity and mortality of the population being studied. The effectiveness of health programs is calculated and expressed as the difference of incapacitation and case-fatality rates between treated and untreated patients (or, in the case of preventive programs, between covered and non-covered persons). This allows health programs, as described by the user, to be ranked according to their effect on those diseases which influence the morbidity (days lost due to illness) and mortality in the population being studied.
The computer dBase III+ program includes only the effectiveness portion of the model, while the costing will have to be completed through a preprogrammed Lotus spreadsheet. In other words, the analysis of public health investments effectiveness will be accomplished through the dBase III+ program and the comparison of their costs will be done on a Lotus spreadsheet; two different computer programs will be used.

Title: Application of Goal Programming to Improve Resource Allocation for Health Services in Papua New Guinea
Author: Young Moon Chai et al
Source: International Journal of Health Planning Management, Vol 4, 1989, pp.81-85
Abstract: This paper describes exploratory work on two allocation models for policy makers in Papua New Guinea using goal programming. The first model allocates national financial resources for health among the 19 provinces. Determinants of the model include health status, population, manpower, and access provisions and previous resource distribution. The second model utilizes the results from the first model to allocate resources among different health activities within each province. Determinants of the model include major health problems of each province and available health resources. The paper concludes with a discussion on the use and implications of the model in the Papua New Guinean situation.

Title: An Input-Output Model for Resources Planning in a Medical Care System
Author: Wong Y.C.
Source: Journal of Medical Systems, Vol 2, No. 2, 1978
Abstract: As medical care delivery systems grow in complexity, the understanding of interaction between entities within the system becomes a key aspect in resource planning. The model presented in this paper is geared to aiding resource planning both at the community or regional level and at the medical facility level. At the regional level the problem is related to the elimination of duplication and the sharing of services. At the medical facility level the concern is the balancing of the supply and demand of services among the departments. The framework of the model is a directed graph with notes representing the service entities and branches representing the interrelationships. The regional level, entities are hospitals, clinics, and centralized supportive units, such as the data center or the central laboratory. At the medical center level, entities are generally departments within the facility. An interactive procedure is used to simulate the propagation effect of a change on all entities. The model

at the medical center level, as implemented in a minicomputer system, was applied to a real problem. The results strongly correlated with another, independent study.

Title: Modeling the growth of long-stay populations in public mental hospitals.
Author: Fisher-WH; Phillips-BF
Address: Department of Psychiatry, University of Massachusetts Medical School, Worcester 01655.
Source: Soc-Sci-Med. 1990; 30(12): 1341-7
Abstract: Long-stay, chronic patients have been a problematic subpopulation in public mental hospitals for over a century. Despite three decades of deinstitutionalization and a major shift toward shorter episodes of hospitalization, there continues to exist a group of patients who experience lengthy hospital stays. As the number of such patients increases in a facility, its ability to provide acute care may be compromised, and the size of this subpopulation must therefore be anticipated. This paper examines the length-of-stay patterns of a sample of public mental hospital admissions through the use of life table analysis, and develops a dynamic modeling algorithm using sample survival function values. Life table analysis revealed a declining hazard function, indicating a diminishing probability of discharge with increased hospital stay. The dynamic model showed that, after 2 years of operation of a hypothetical facility, current length-of-stay patterns would generate an inpatient population 40% of which had been hospitalized for over 6 months. Goodness-of-fit tests comparing the algorithm's forecast with actual hospital utilization data showed its predictions to be reliable. The authors discuss the use of this methodology to anticipate the effects of programmatic or other types of changes in mental hospitals, and also suggest other types of settings where such modeling techniques might profitably be applied.

Title: Catastrophe modeling of the accident process: evaluation of an accident reduction program using the occupational hazards survey.
Author: Guastello-SJ
Address: Department of Psychology, Marquette University, Milwaukee, WI 53233.
Source: Accid-Anal-Prev. 1989 Feb; 21(1): 61-77
Abstract: The report details a catastrophe theory model of the accident process with empirical validation. Research has shown that a substantial percentage of occupational accidents are the result of human error. In an effort to explain and predict such errors in a systematic manner, an accident process model based on the cusp catastrophe is developed and tested. The model offers several unique and useful properties: (1) It proposes that changes in accident rates for work groups are the result of a nonlinear dynamic process. (2) The distribution of accident rates is bimodal, with one model near zero and the other at some higher level. (3) Changes in accident rates are predicted from four sources: (i) ambient danger and hazard levels, (ii) variables that impact upon human performance capability, (iii) initial accident rates, and (iv) the mathematical function that interrelates those variables. (4) The mathematical model has inherent properties that allow for causal inference. Environmental and human performance factors can be operationalized as sets of more specific variables.

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